Zeyang Yu

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Carbon & Composite Group
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TECHNIQUES

- **Polymer Compounding**: Extrusion/Injection/Compression, Casting/Curing
- **Coating Techniques**: Spray Coating, Blade Coating, Layer-by-Layer Method
- **Surface Functionalization**: Plasma Treatment, Wetting, Sizing, Electrochemical Functionalization, Grafting and Deposition.
- **Characterization Techniques**: SEM, EDS, AFM, Optical Microscopy, TGA, DSC, FTIR, Raman Spectroscopy, XRD, DMA, Mechanical Property Test (Tensile, Flexural), BET, Thermal Diffusivity Analysis, Gas Barrier Analysis, Single Filament Pull-out Test, Interfacial Shear Strength Measurement.
- **Software**: Matlab, Origin, Auto CAD, Microsoft Office

EMPOLYMENT

- **Postdoctoral Research Associate** June. 2021-Present
  Physical Sciences Directorate
  Oak Ridge National Laboratory

- **Postdoctoral Research Associate** Sept. 2019-June. 2021
  School of Chemical and Biomolecular Engineering
  Georgia Institute of Technology

EDUCATION

- **Doctor of Philosophy**, Chemical Engineering Aug. 2013-Aug. 2019
  Michigan State University, East Lansing, MI, U.S.A
  Dissertation: Graphene Nanoplatelet Based Polymer Composites and Their Multiple Applications
  GPA: 3.7/4.0

- **Bachelor of Science**, Chemical Engineering Sept.2009-Jul. 2013
  Beijing University of Chemical Technology, Beijing, China
  Thesis: Hydrothermal Method to Prepare Silica-Graphene Aerogel and Its Application in Thermal Insulation
  GPA: 3.7/4.0

AWARD, SCHOLARSHIPS, AND PUBLICATIONS

Dissertation Completion Fellowship 2019
Michigan State University, East Lansing, MI

Outstanding Student of College of Chemical Engineering 2011
Beijing University of Technology, Beijing, China.

NHU Enterprise Scholarship 2010, 2011
Beijing University of Technology, Beijing, China.

Second-class People's Scholarship 2010
Beijing University of Technology, Beijing, China.

Presentation

Zeyang Yu, Lawrence Drzal, Andre Lee. "GnP-TPU Composite Films for Packaging Applications" SPE ANTEC conference 2019
Zeyang Yu, Lawrence Drzal. "Functionalized graphene oxide as coupling agent for graphene nanoplatelet/epoxy composites". CHEMS Symposium, Michigan State University 2018.
Zeyang Yu, Lawrence Drzal. "Graphene composite paper used as the electrode materials for the electrostatic actuators" IACMI composite conference 2017.
Zeyang Yu, Lawrence Drzal. "Graphene composite paper used as the electrode materials for the electrostatic actuators" SPE ACCE conference 2017

Journal Articles

1.***Zeyang Yu***, Yue Ji, J. Carson Meredith. "Multilayer Chitin–Chitosan–Cellulose Barrier Coatings on Poly(ethylene terephthalate)" ***ACS Applied Polymer Materials 2022 4 (10), 7182-7190.***
2.***Zeyang Yu***, Yue Ji, Violette Bourg, Julien Bras, Mustafa Bilgen, J. Carson Meredith. "Chitin- and Cellulose-Based Sustainable Barrier Materials: A Review" ***Emergent Materials. 2020 Dec 9:1-8.***
3.***Zeyang Yu***, Lawrence Drzal, Andre Lee. "GnP-TPU Composite Films for Packaging Applications" Submitted to Journal of Materials Science.
4.***Zeyang Yu***, Lawrence Drzal. "Functionalized graphene oxide as coupling agent for graphene nanoplatelet/epoxy composites". ***Polymer Composites. 2020 Mar;41(3):920-9.***
5. ***Zeyang Yu,*** Lawrence Drzal. "Graphene nanoplatelet composite 'paper'as an electrostatic actuator" ***Nanotechnology 29, no. 31 (2018): 31LT02.***
6. Yongsoon Shin, Yao Qiao, Nathan Canfield, ***Zeyang Yu***, Harry M Meyer III, Daniel R Merkel, Ethan K Nickerson, Nihal S Kanbargi, Angel Ortiz, Amit K Naskar, Kevin L Simmons. "Significant Slowdown of Plasma-Optimized Surface Energy Deactivation by Vacuum Sealing for Efficient Adhesive Bonding" ***Composites Part B: Engineering. 2022 May 30:110001.***
7.. Kanbargi N, Hoskins D, Gupta S, ***Yu Z***, Shin Y, Qiao Y, Merkel DR, Bowland CC, Labbé N, Simmons KL, Naskar AK. A renewable lignin-based thermoplastic adhesive for steel joining. ***European Polymer Journal. 2023 May 8;189:111981***.
8. Gupta S, Mahapatra A, Angelopoulou P, Kearney L, ***Yu Z***, Naskar AK, Bowland C. A versatile fiber coating process for efficient fabrication of multifunctional composites. InNondestructive Characterization

and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XVII 2023 Apr 18 (Vol. 12487, pp. 147-157). SPIE.

RESEARCH

RESEARCH INTERESTS

- Carbon materials based multi-functional composites and their applications
- Biobased materials used as the fillers and coatings for packaging applications
- Sustainable adhesives and coatings
- Interfacial design to improve the dispersion and bonding strength between fillers and matrix
- Microelectromechanical actuator and electrode materials

RESEARCH PROJECT

Smart Repair for Gas Transport Pipe (Founded by DOE),
Oak Ridge National Laboratory

The overarching goal of this project is to develop novel smart structural composite coating materials, coupled with a deposition system and non-destructive multiscale inspection technologies, resulting in a robust structural repair solution for the reinvigoration of gas distribution pipelines.

- The clay particles and carbon fiber were incorporated into the fast-curing epoxy system to improve the sag-resistance and mechanical properties.
- Various fillers, basalt fiber, fiber glass, graphene nanoplatelets, etc. were selected as the promising reinforcements.
- Investigated the effect of filler loading, mixing conditions, degas methods, curing temperature, curing agents on the final properties of epoxy-based coatings.
- Designed robot-assisted coating tools to spray coat the developed epoxy composites onto the inner sides of gas transport pipes.

Biobased Adhesives for Joints Part between Revit and Metal Plate (Founded by DOE, collaborated with Pacific Northwest National Laboratory).
Oak Ridge National Laboratory

The objective is to significantly improve the performance and productivity of adhesive bonding in high volume auto body assembly, and to develop better tools for adhesive performance, joint design, and lifetime prediction. Develop the biobased, sustainable adhesive is long-term goal.

- Lignin was incorporated into the acrylonitrile butadiene rubber (NBR) to prepare thermoplastic biobased adhesive.
- With proper lignin and acrylonitrile content, the lap shear stress can reach ~14 MPa.

- Multiple surface treatment techniques (plasma, base etch, anodizing, primer layer coating) were applied to increase the interfacial bonding strength.
- Other biobased thermoplastic matrix and fillers were planned to be analyzed and used to prepare green adhesives.

Modified the properties of carbon fiber and designed multi-functional carbon fiber composites (Founded by DOE).
Oak Ridge National Laboratory

Carbon fibers (CFs) have been widely utilized to fabricate lightweight, high-strength, and high toughness composites which are desirable in the aerospace and automotive sectors. The mechanical properties of a CF-reinforced composite are fundamentally determined by the intrinsic properties of the fiber and the interfacial bonding strength of the fiber with polymer matrix. The objective of this research is to create a biobased coating material through electrochemical deposition method to enhance the interfacial properties between CFs and polymer matrix.

- Applied chemical (acid, based), electrochemical, and physical (plasma, sizing) methods to functionalize the carbon fiber surface.
- Coated the surface of carbon fiber with various polymers to improve its interfacial adhesion with different matrix.
- Developed the biobased coatings and adhesives which used the functionalized carbon materials as the reinforcement.
- Created porous carbon materials which are applicable for the electrical, thermal and adsorbing applications.

Polysaccharides Based Materials Used as the Biobased Coatings for Sustainable Packaging (Founded by Nestle, Winpak, and Niagara)
Georgia Institute of Technology

The accumulation of synthetic plastics in gas-barrier packaging applications is causing a serious environmental problem. It is driving research efforts to develop biodegradable films and coatings. Cellulose and chitin are the first and second most abundant naturally occurring biopolymer which are used here as the coating materials for polymer substrates.

- Extracted the chitin/cellulose nanocrystals from food waste or woods. Adjusted the experimental conditions to control the size of nanomaterials.
- Used blade coating/spray coating to prepare biobased coated polymer films, the oxygen permeability can be lower than 1 cm^3 μm m^{-2} day^{-1} kPa^{-1}. (The commercial PET packaging films has a value of 16 cm^3 μm m^{-2} day^{-1} kPa^{-1})
- Applied multiple methods to control the alignment of nanowires and adjust the overall barrier properties, mechanical properties, conductivities based on different actual requests.
- Used the thermal treatment to remove the bound water and the barrier property could be further improved over 50%.
- The biobased coatings could be recycled by immerse in the water/NaOH solution.

Extruded Graphene Nanoplatelets (GnP)-Thermoplastic Polyurethane (TPU) Composite Film as the Electronic Packaging Material (Founded by Ford).
Michigan State University

The increase of miniaturization and rise of energy density for electronic facilities with packed structure have caused a need for high-performing thermal conductive packaging material that can transfer heat outside the device efficiently. A polyurethane (TPU) - graphene (GnP) composite film were developed for car batteries which offered good mechanical properties, thermal conductivity, and gas barrier property.

- Prepared thermally conductive GnP-TPU composite packaging films using extrusion. Improved the thermal conductivity by 350%, decreased the oxygen permeability by 75%, and enhanced tensile modulus by 950% compared to neat TPU.
- Investigated the effect of extrusion speed, the temperature on the alignment of graphene nanoplatelets, and the crystallinity of polyurethane-based composite.
- Investigated the synergistic effect of graphene-carbon nanotube on improving the thermal conductivity, electric conductivity, and mechanical properties of polyurethane composite film.
- Successfully created features onto the composite films for improving the thermal convection in an air-cooling system through the hot compression method.
- Simulated the effects of aspect ratio, materials, arrangement, and density of features on thermal convection.
- The heat transfer efficiency is two time better than the commercial battery films.

Improved the Mechanical Property of Epoxy Composite and Investigated the Interfacial Design Between Fillers and Epoxy (Internal Grants)
Michigan State University

Epoxy resin, one of most widely used thermoset polymers, is known for its good mechanical and thermal properties, electrical insulation, high adhesive strength and chemical and corrosion resistance. However, its toughness, strength, resistance to crack propagation are still needed to be further improved in order to satisfy the increasing demands in high-performance applications. GO was used as the surfactant here to modify the interfacial properties between graphene nanoplatelets and epoxy matrix. Different diamines were applied to control the toughness and modulus of the composites, targeting at different applications.

- Investigated the mechanical property for Epoxy resin cured with different diamines (D400, D2000) and curing process.
- Analyzed synergistic effect of using graphene oxide/graphene couple to reinforce the properties of Epoxy composites.
- Functionalized graphene oxide/graphene with different diamines and investigated their effect on the curing process/mechanism and mechanical properties of Epoxy composites.
- Achieved 57%, 25% improvements in tensile and flexural modulus with functionalized graphene oxide-graphene nanoplatelets couple as the filler at 0.86wt% loading compared to neat epoxy. While the toughness increased up to ~110% compared to simply using graphene nanoplatelets as the filler.

Graphene Nanoplatelets-Epoxy Composite Flexible 'Paper' as an Electrostatic Actuator (Internal Grants)
Michigan State University

Because of high electric conductivity, the graphene nanoplatelets are widely used as the electrode materials. In this work, the graphene paper was prepared and used as the moveable arms for the electrostatic actuators. This electro-mechanical system is capable moving a suspended structure precisely and cause less energy consumption.

- Developed an easy, fast way to construct graphene paper-based flexible electrostatic actuator in millimeter-scale
- Prepared Epoxy coating layer using different diamines to adjust the stiffness of the electrode.
- Utilized electrostatic mechanisms to increase the actuating stroke, avoiding the pull-in effect existed in traditional electrostatic actuators.
- Improved the actuating performance by increasing the surface area of electrodes and the dielectric constant of the insulating layer.
- Achieved an improvement of up to 400% in actuating performance (output work).
- Investigated on structure designing of actuators for better performance.

TEACHING EXPERIENCE

- Teaching Assistant
  CHE 473 Chemical Engineering Processing Control **Sept. 2013-Dec. 2013**
  Responsibilities: Organized computer lab, simulation section, and process control lab section
- Teaching Assistant
  CHE 804 Foundations in Chemical Engineering **Jan. 2018-May. 2018**
  Responsibilities: Organized students study group, grading, and office hours

SERVICES

Ad-hoc Reviewer for Refereed Journals

1. ACS Applied Nano Materials
2. ACS Omega
3. Powder Technology
4. Journal of Applied Polymer Science
5. Polymer Composites